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Original Article

Changes in Angulation and Eruption Space of Developing Mandibular Third Molars Following Twin Block Treatment

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Main Points

- The development of third molars and their interaction with the rest of the dentition reveals a great challenge to general dentists as well as orthodontists.
- Despite the major controversy regarding the effect of functional treatment on the mandible, yet, there is a paucity of data concerning their effects on the developing mandibular third molars.
- Twin block bite jumping appliances have a non-significant influence on the angulation of the developing mandibular third molars.

ABSTRACT

Objective: The aim of this study was to assess the effects of twin block functional appliance three dimensionally on mandibular third molars angulation and eruption space.

Methods: This retrospective study included cone beam computer tomography (CBCTs) of 34 Class II females (11.84 ± 0.94 years) who were divided into 2 groups. The first group received a standard twin block appliance (intervention group), while the other was considered as a control. CBCT images were obtained for all patients before the start of the intervention (T0) and after the active phase (9.4 ± 1.33 months) in the intervention group and at the beginning (T0) and after the observation period (T1) in the control group (8.12 ± 2.72 months). Measurements for the retromolar space were performed on the axial views, while those for molar angulation were performed on sagittal views as well as CBCT panoramic reformatted images.

Results: Both twin block and control groups showed non-significant changes in the angular measurements (sagittal L8/MP° and panoramic L8/MP°) denoting lack of change in the angulation of the third molars in relation to the mandibular plane after treatment. On the other hand, retromolar spaces showed a statistically significant increase ($P \leq .05$) in both groups. The change was much significant for the twin block group, measuring 1.95 mm and 1.56 mm on the right and left sides, respectively, as compared to the control group which revealed less than 1 mm increase in the retromolar space on both the right and left sides.

Conclusions: In spite of their positive impact on the retromolar space, twin block bite jumping appliances have a non-significant influence on the angulation of the developing mandibular third molars.

Keywords: Cone beam CT, functional orthodontic appliance, third molar, three-dimensional imaging

INTRODUCTION

The development of third molars and their interaction with the rest of the dentition reveals a great challenge to general dentists as well as orthodontists. Their eruption position and pattern may influence or be influenced by orthodontic treatment. Hence, their direct involvement in treatment planning is mandatory.

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Lower third molars are considered the second most commonly impacted teeth following upper third molars.[1] A minimum of one impacted mandibular third molar has been reported in about 73% of young adults. The prevalence of impaction varies in different populations between 18% and 32%.[2] Formation of third molars begins at about 8-10 years of age, with a degree of variation ranging from 5 to 14 years, which is relatively consistent with the time advocated for mandibular functional treatment to correct sagittal discrepancies, especially in females.

It is generally believed that lack of space between the distal surface of the erupted second molar and the ascending ramus constitutes the major factor for the high frequency of mandibular third molar impaction.[3] The smaller the space available, the greater the likelihood of impaction.[4]

Class II malocclusion is a frequently seen problem in daily orthodontic practice.[1] It could have a negative impact of variable degrees on patient esthetics, function, as well as psychology. Recognition of mandibular deficiency as the major contributing factor for Class II structural etiology[5] has prompted the increased implementation of bite jumping functional appliances. The major goal of functional appliance therapy is to enhance or to redirect the growth of the mandible in a favorable direction.

A multitude of functional appliances has been presented in the orthodontic literature for the correction of Class II malocclusion.[6,7] The technique of fabrication, method of bite construction, as well as patient compliance are the key factors that govern the differences in the outcomes of various functional appliances. The twin block functional appliance (TB), originally developed by Clark,[8] has gained increasing acceptance. The appliance consists of maxillary and mandibular acrylic plates with interlocking bite blocks that posture the mandible forward on closure.

Despite the major controversy regarding the effect of functional treatment on the mandible, yet, there is an undeniable evidence of mandibular length increase after treatment with several functional appliances.[9] Meanwhile, clinical results remain to be the main impetus for their indispensable use. The literature is replete with articles reporting various effects of functional treatment on mandibular dentition,[10,11] yet, there is a paucity of data concerning their effects on the developing mandibular third molars eruption space and angulation.[12] Accordingly, the aim of this study was to assess the effects of TB functional appliance three dimensionally (3D) on developing mandibular third molar eruption space and angulation.

METHODS

Trial Design

The radiographs for this retrospective study were collected from the records of patients treated at the outpatient clinic of the Department of Orthodontics, Cairo University. The CBCTs were taken for those patients in the course of treatment with TB appliance for another study to evaluate skeletal, dentoalveolar, and temporomandibular joint changes.[10] This single-blind study was approved by the Research Ethics Committee (No. 130811), Faculty of Dentistry, Cairo University, Egypt, and participation consent forms were signed by the patients' parents or their legally authorized representatives.

Sample Size, Eligibility Criteria, and Settings

Sample size calculation was done with an alpha value of 0.05 and a power of 80% based on the study conducted by Bayram et al.[13] Power analysis showed a minimum sample of 15 patients in each group. Patients who met the eligibility criteria were included in the sample (Table 1).

A total of 17 patients were included in each group with a total sample size of 34 patients. A standard TB appliance manufactured according to Clark[8] was confirmed. The exact active treatment time together with the patients' compliance with the appliance wear was acknowledged from the patients' follow-up records. CBCT images of 17 untreated, clinically matching control patients were obtained from a control databank in the same institute. Lateral cephalometric radiographs constructed from CBCT images were used to assess the baseline characteristics of the patients (Table 2).

CBCT Imaging and 3D Analysis

CBCT images of the involved patients were confirmed to be acquired using the same machine (Sirona Dental Systems, Bensheim, Germany). Parameters of the CBCT scanner were set according to the recommendations of De Vos et al.[14] and provided a minimal set of CBCT device-related parameters to minimize the radiation dose to the minimum following the as low as reasonably achievable guidelines. CBCT images were obtained for all patients before the start of treatment (T0) and after the active phase of the appliance (T1) in the treatment group and at the beginning (T0) and after the observation period (T1) in the control group. The functional phase lasted for 9.4 $\pm$ 1.33 months and the observational period for the control group was 8.12 $\pm$ 2.72 months.[10] The CBCT images were then converted to Digital Imaging and Communications in Medicine (DICOM)

Table 1. Eligibility criteria of patients included in the study

Inclusion Criteria	Exclusion Criteria
Females mean age: 11.84 $\pm$ 0.94 years	History of previous orthodontic treatment
Convex profile with retruded mandible	History of TMJ disorders
Full unit Class II molar and canine relationship	Systemic disease or chronic medication
Stage 3 Cervical Vertebrae Maturation Index (CVMI) as verified from lateral cephalometric radiographs	Congenitally missing or extracted teeth
Erupted mandibular second molars	
Arch length discrepancy $\leq$ 5 mm	
Third molar crown formation completed	
Active treatment between 8 and 10 months	

Table 2. Baseline characteristics of the sample compared with independent *t*-test

	Twin Block		Control		
	Mean	SD	Mean	SD	*P*
Age (years)	11.89	1.85	11.27	2.19	.335
SNA (°)	81.27	3.58	81.75	3.52	.703
SNB (°)	73.00	3.24	73.97	2.30	.326
ANB (°)	8.28	1.19	7.51	1.81	.171
Go-Gn (mm)	74.18	4.17	74.52	3.13	.791
SN/MeGo (°)	43.69	3.38	38.9	4.5	.051

SD, standard deviation; SNA, Sella. Nasion. Point A; SNB, Sella. Nasion. Point B; ANB, Point A. Nasion. Point B; Go-Gn, Gonion-Gnathion; SN/MeGo, Sella. Nasion/ Menton.Gonion.

format and processed into volumetric images using Invivo Anatomage image processing software version 5.2 (Anatomage, San Jose, Calif, USA). Multiplanar sagittal, coronal, and axial projections were generated. A customized craniofacial analysis was developed specifically for this research. Measurements for both treatment and control groups at (T0) and (T1) were performed on the axial views, CBCT panoramic reformatted image, as well as the sagittal views (Table 3). The assessors were blinded during the analysis, and the measurements were performed by the same observer twice at 2 weeks intervals and by another observer.

The linear measurements for the retromolar space (RMS) were performed on the axial view following Marchiori et al.[4] method. The measurement was taken after scrolling between the axial cuts till positioned parallel to the occlusal plane at the level of interproximal contact points of permanent molars and premolars. At this level, 2 tangent lines were drawn from the center point of mandibular canal across the second molars to be intersecting at a point midway between central incisors. The distance between the distal surface of right and left second molar and

Table 3. Definitions of the included landmarks and measurements

Measurement	Definition
L8 (long axes of the third molar buds)	The line extending from the point of intersection between the converging tangents to the mesial and the distal outlines of the molars and the mid-point on the occlusal surface
MP (mandibular plane)	The line extending from the Menton, the most inferior point at the mandibular symphysis, to the Gonion, the most posterior inferior point at the outline of the angle of the mandible
Panoramic RL8/ MP°	The angle formed between long axis of the right third molar and the right mandibular plane line as viewed from CBCT panoramic reformatted image
Panoramic LL8/MP°	The angle formed between long axis of the left third molar and the left mandibular plane line as viewed from CBCT panoramic reformatted image
Sagittal RL8/MP°	The angle formed between long axis of the right third molar and the right mandibular plane line as viewed from the sagittal view
Sagittal LL8/MP°	The angle formed between long axis of the left third molar and the left mandibular plane line as viewed from the sagittal view
RRMS (right retromolar space)	The linear distance between the most convex point on the distal surface of the right second molar and anterior border of the right ramus as viewed from the specified axial view
LRMS (left retromolar space)	The linear distance between the most convex point on distal surface of the left second molar and anterior border of the left ramus as viewed from the specified axial view

RL8, right lower third molar; LL8, left lower third molar

Figure 1. The axial section with linear measurements of the right and left retromolar spaces

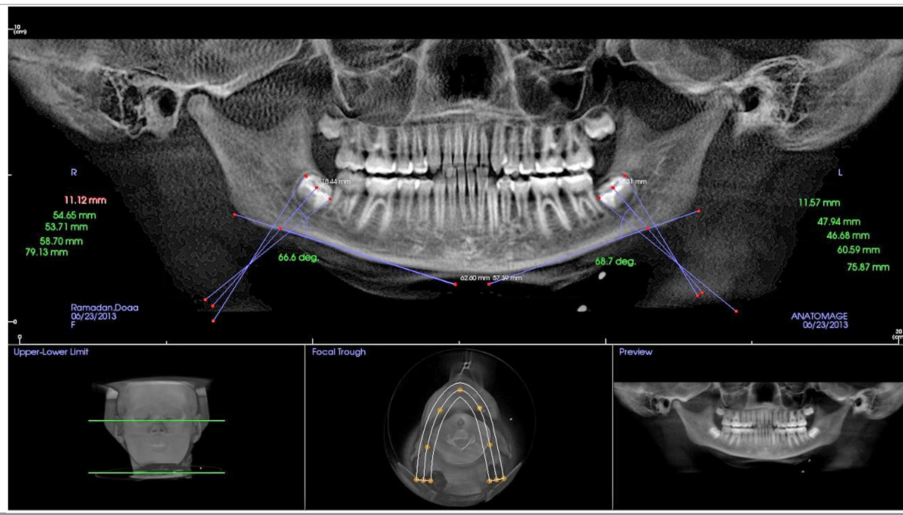

Figure 2. The panoramic reformatted image with angular measurements of the right and left sides

anterior border of the right and left ramus was measured (RRMS and LRMS axial), respectively (Figure 1).

The angular measurements were performed on CBCT panoramic reformatted image (Figure 2) as well as the sagittal view (Figure 3) after adjustment of the axial orientation line to be along the occlusal plane, while the coronal orientation line midway along the long axis of the mandibular third molar, and the sagittal orientation line from mandibular third molar to a point midway between central incisors (Figure 4).

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences version 22.0 (IBM SPSS Corp., Armonk, NY, USA) for windows. Numerical data were explored for normality by checking the data distribution, calculating the mean and median values, and using Kolmogorov–Smirnov and Shapiro–Wilk tests. Data showed parametric distribution, so it was represented by mean and standard deviation values. Inter- and intra-group comparisons were done using independent and paired *t*-tests, respectively. For inter- and intra-observer reliability, concordance correlation coefficients including 95% confidence limits were used.

RESULTS

Intra- and interobserver reliability tests showed an excellent concordance correlation (0.99). Both control and TB groups showed non-significant changes ($P > .05$) in the angular measurements (sagittal L8/MP° and panoramic L8/MP°) denoting lack of change in the angulation of the developing third molars in relation to the mandibular plane after treatment (Table 4). On the other hand, both RRMS and LRMS showed a statistically significant increase ($P \leq .05$) in both groups. The change was greater for the TB group, measuring 1.95 mm and 1.56 mm on the right and left sides, respectively, as compared to the control group which revealed a less than 1 mm increase in the RRMS and LRMS (0.86 mm and 0.34 mm, respectively) (Table 4).

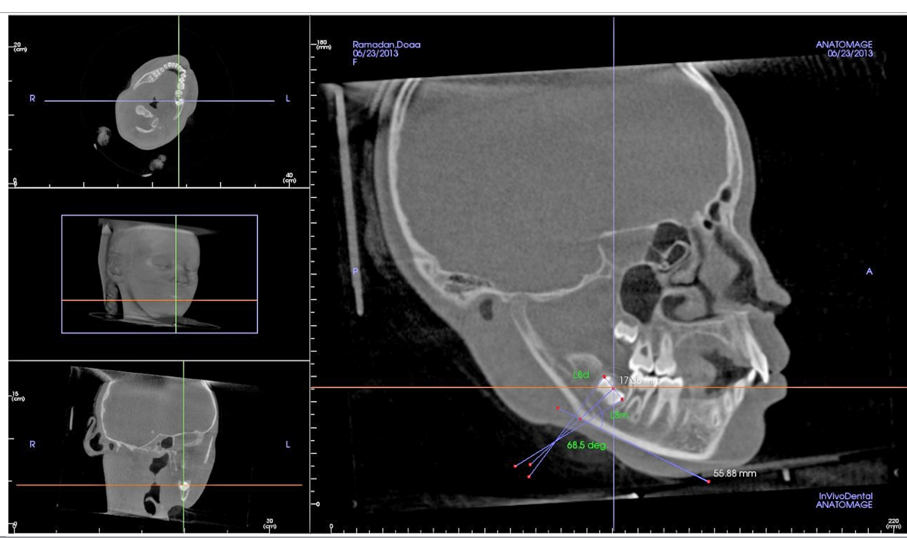

Figure 3. The sagittal section with angular measurements of the left sides

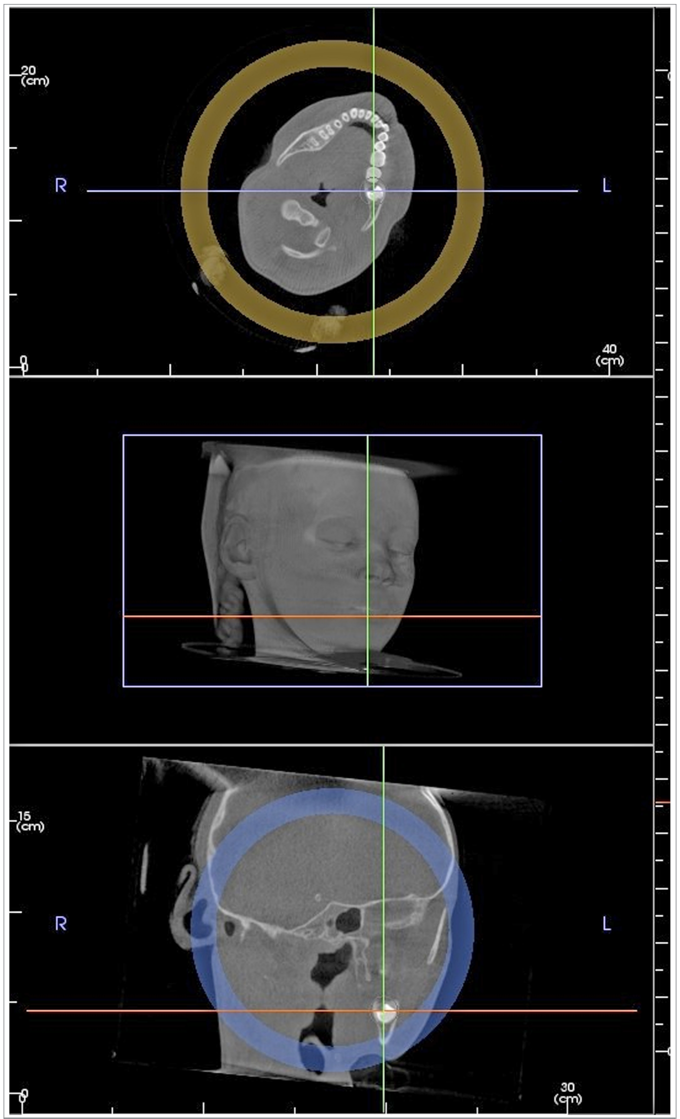

Figure 4. The axial and coronal sections illustrating the adjustment of the axial orientation line, sagittal orientation line and coronal orientation line

Additionally, non-significant changes ($P > .05$) were reported between the TB and the control groups concerning molar angulation in the panoramic and sagittal views' measurements before and after the study period (Table 5).

DISCUSSION

Functional orthopedic appliances have been used in growing individuals with skeletal Class II aiming at establishing muscular balance, eliminating oral dysfunction, and/or allowing for the lengthening of the mandible. Despite the controversial conclusions of published systematic reviews, improvement in mandibular growth together with proclination of the lower incisors following the use of TB functional appliances has been reported.[6,14]

There is a paucity of data concerning the optimum timing for functional jaw orthopedics; however, there is a consensus that this treatment modality better be commenced around the period of puberty[16,17] which in turn is coincident with the time of development of mandibular third molars.[18]

The current study was conducted to evaluate the effects of TB functional appliance treatment on developing mandibular third molar eruption space and angulation. Similar studies have been conducted to assess changes in the position of third molars associated with extraction versus non-extraction orthodontic treatments,[19-22] and limited studies were concerned with the effect of functional treatment on third molar position and angulation.[12] Panoramic radiograph was the common tool used for the evaluation in those studies despite its inherent weakness of 2-dimensional (2D) representation of 3D objects.[23]

In their systematic review, Araujo et al.[23] reported the usefulness of 3D imaging in providing additional information on the relationship between lower third molar and neighboring structures. Likewise, Marchiori et al.[4] confirmed the high accuracy of CBCT imaging in analyzing the third molar development, crown size, and jaw dimensions. They demonstrated a method for measuring the RMS on the axial views from CBCT images. Their method for measuring the RMS together with the method of Mendoza-García et al.[24] for measuring the third molar angulation with the mandibular plane as viewed on panoramic radiographs was implemented in the current study.

Table 4. Mean and standard deviation of angular and linear measurements before and after twin block treatment and observation period using independent t-test

Linear and angular measurements	Twin Block group					Control group				
	Before		After			Before		After		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Sagittal RL8/ MP°	61.82	14.58	63.04	15.06	0.116	72.3	10.63	74.23	9.76	0.224
Sagittal LL8/ MP°	72.67	7.53	77.67	9.22	0.072	70.97	8.88	71.83	9.28	0.126
Panoramic RL8/ MP°	64.87	5.7	67.36	5.57	0.163	71.9	6.27	73.83	7.97	0.218
Panoramic LL8/ MP°	76.8	9.55	81.08	9.8	0.147	70.45	5.63	72.1	7.23	0.194
Axial RRMS (mm)	11.61	2	13.56	2.35	0.001*	8.43	3.2	9.23	3.5	0.018*
Axial LRMS (mm)	10.84	3.04	12.42	2.64	0.001*	6.71	3.49	7.05	3.41	0.021*

*Significance at $P \leq .05$.
SD, standard deviation; LRMS, left retromolar space; RRMS, right retromolar space.

Table 5. Intra and inter group comparison of mean and standard deviation of panoramic and sagittal views' measurements for the Twin Block and the control group

	Group	Imaging Method: Panorama (Mean ± SD)	Imaging Method: Sagittal (Mean ± SD)	*P*
Before	TB	70.38 ± 9.62	68.15 ± 11.24	.338
	Control	71.07 ± 5.44	71.54 ± 8.81	.765
P		.863	.499	
After	TB	73.69 ± 10.31	71.23 ± 12.68	.228
	Control	72.84 ± 6.94	72.86 ± 8.74	.989
Difference		0.850	1.630	
P		.780	.666	

Significance value (*P*-value)
SD, standard deviation; TB, twin block

The measurement was taken after scrolling between the axial cuts till positioned parallel to the occlusal plane at the level of interproximal contact points of permanent molars and premolars. This would not have been possible to accomplish with 2D imaging using panoramic radiography. Additionally, the main advantage of 3D imaging is that it offers cuts in the axial, coronal, and sagittal planes that allow for the better localization of intended objects.

It has been reported that the mandibular third molar starts its development in the ramus of the mandible with its occlusal surface having an angle with the mandibular plane. In order to erupt with a normal occlusal relationship, the third molar should experience an uprighting movement, the degree of which depends on its original angulation to the mandibular plane.[25]

The baseline characteristics for the study groups presented in Table 2 showed no statistically significant difference concerning any of the considered measurements. This in turn reflected homogenous sample with no remarkable differences.

Results from the current study revealed non-significant changes in the angulation of the third molars in relation to the mandibular plane following the study period in both groups. This was consistent with the results of Cornell and Park[26] who reported that 4 out of 6 included studies in their systematic review showed no significant difference in mandibular third molars angulation between the extraction and non-extraction treatments. These results could be explained by the observation reported by Silling[27] who emphasized that important changes in the axial inclination of the mandibular third molar take place between the ages 16 and 18 years when the bud has reached a point in close proximity to the distal aspect of the second molar, the condition that was not established in the current study. On the other hand, Aslan et al.[12] reported a significant uprighting of the third molar by 4.28° following treatment with Forsus fatigue resistant device with no significant difference compared to the control.

Despite many factors that could interfere with the eruption of mandibular third molars, the available space at the posterior borders of the dentition is considered the most decisive. The difference detected in the RMS between the 2 groups at the baseline could be attributed to a tooth size/arch length discrepancy. In the current study, the RMS showed an increase between 0.34 mm and 0.80 mm for the control group as compared to 1.58 mm and 1.95 mm for the TB group during the study period. This increase in RMS could be associated with the increase in the corpus length following the use of TB appliance as reported by Elfeky et al.[10] who attributed the overall mandibular skeletal changes to the increase in mandibular length by 3.19 mm. Cozza et al.[15] demonstrated comparable results in their systematic review to investigate mandibular changes produced by functional appliances in Class II malocclusion. Their results revealed an increase of mandibular length by 0.23 mm/month following the use of TB appliance. Likewise, Ehsani et al.[11] and D'Antò et al.[28] acknowledged a mandibular increment increase by 2.9 mm/year and 2.9 mm, respectively, following the use of the same appliance. Another possible and more advocated explanation for the increase in the RMS could be the mesial drift of the entire dental arch with forward migration of the mandibular first molars and proclination of the mandibular incisors.[6,10,11] A similar finding was presented by Toth et al.[30] who reported forward movement of the lower incisor by 0.7 mm during TB treatment and Aslan et al.[12] who reported an 8.79° increase in incisors inclination following the use of Forsus fatigue resistant device. Additionally, Aslan et al.[12] reported a significant greater increase in the RMS at the end of the treatment (from 0.37 mm to 0.65 mm; 0.28 mm) compared to the control group (from 0.44 mm to 0.54 mm, 0.10 mm).

The position and eruption of mandibular third molars in relation to different orthodontic treatment mechanics continue to be a controversial issue. Different orthodontic treatment mechanics establish different space conditions in the dental arches that could affect the eruption of mandibular third molars hence the decision of their prophylactic extraction.

Limitations in the current study should be considered when interpreting the results. First, the data were collected from the records of patients treated at the outpatient clinic of the Department of Orthodontics, Cairo University,[10] and hence, randomization of the sample was not feasible. Only female patients were recruited which despite helping in the validation of the comparison through precluding possible gender effect on growth and development, yet, it could limit the generalizability of the results. Moreover, a longer assessment duration could have better elucidated the actual impact of the appliance on the developing molars.

CONCLUSION

The use of TB bite jumping appliances for the treatment of growing Class II patients does not seem to affect the angulation of the developing mandibular third molars despite its positive impact on the RMS available for their eruption.

Ethics Committee Approval: Ethics committee approval was received from the Research Ethics Committee of the Faculty of Dentistry, Cairo University, Egypt (No. 130811).

Informed Consent: Written informed consent was obtained from all patients' parents or legally authorized representatives.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – F.A.E.S.; Design – H.Y.E.; Data Collection and/or Processing – H.Y.E.; Analysis and/or Interpretation – E.A.A.S.; Writing – F.A.E.S.; Critical Review – F.A.E.S.

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